



MEDIA RELEASE

Embargoed by the journal *Proceedings of the Royal Society B: Biological Sciences* for release at **00.01 BST Weds 15th July**.

Author Contacts:

Lindsay E. Zanno, John Caldwell-Meeker Postdoctoral Fellow, Department of Geology, The Field Museum. Phone: office (312) 665-7665; cellular (773) 750-7715. Email: lzanno@fieldmuseum.org

David D. Gillette, Colbert Curator of Paleontology, Museum of Northern Arizona. Phone: Office: (928) 774-5211 ext. 246; cellular (928) 853-5441. Email: dgillette@mna.mus.az.us

L. Barry Albright III, Instructor, Department of Chemistry and Physics, University of North Florida. Phone: office 904-620-2238; cellular (904) 710-0251. Email: lalbrigh@unf.edu

Alan L. Titus, Monument Paleontologist, Grand Staircase-Escalante National Monument, Bureau of Land Management. Phone: office (435) 644-4332; cellular (435) 644-4350. Email: Alan_Titus@blm.gov

Public Relations:

Nancy O'Shea, Public Relations Director, The Field Museum. Phone: office (312) 665-7103. Email: noshea@fieldmuseum.org

Joanna Norris, Media Relations and Events, University of North Florida, Phone: office (904) 620-2102; Email: jnorris@unf.edu

Dinosaur art, c. Victor Leshyk 2009. Additional art available from Victor Leshyk (contact David D. Gillette).

Giant “Reaper” Dinosaur Unearthed in Utah Desert

Research Suggests Iconic Predators like *Velociraptor* Evolved from Plant-Eating Ancestors

A multi-institutional team of scientists report discovery of a new species of the bizarre and enigmatic dinosaurs known as therizinosaurs (“reaper-lizards”) in the journal *Proceedings of the Royal Society B: Biological Sciences* (online publication date July 15th). The new dinosaur, dubbed *Nothronychus graffami* (no-thrown-EYE-kus GRA-fam-eye), is represented by the most complete remains of a large-bodied therizinosaur yet discovered worldwide and is one of only three species of this rare type of dinosaur found in North America to date. The species is named for the discoverer of the skeleton, Merle Graffam, of Big Water, Utah, and a member of the Museum of Northern Arizona’s excavation team.

An Unusual Family—A Mysterious Beast

Therizinosaurs are intriguing because they belong to a group of dinosaurs known as theropods or “predatory” dinosaurs—a group that includes such legendary members as *Tyrannosaurus rex* and *Velociraptor*—yet scientists think therizinosaurs were plant-eaters not predators, says Lindsay Zanno, principal author of the study and paleontologist at the Field Museum. Advanced therizinosaurs, like *N. graffami* had odd bodies. Their small heads had a keratinous beak and tiny leaf-shaped teeth. They had a long neck, an enormous, barrel-shaped gut, stumpy legs, and a short tail; but most impressive were their enlarged scythe-shaped hand claws—reaching up to a meter in length on *Therizinosaurus cheloniformis*, an advanced Asian cousin of *Nothronychus graffami*. With nine-inch long (22 cm) claws on its hands, *Nothronychus graffami* was no slouch either, “You wouldn’t want to run into this guy in a dark alley” says Zanno. Zanno was a member of the scientific team that named the most primitive therizinosaur known to date—*Falcarius utahensis*—in the journal *Nature* in 2005. The remains of *Falcarius* were also discovered in the state of Utah.

The bizarre anatomy of therizinosaurs prompted controversy over their evolutionary relationships for decades, but the recent discovery of primitive therizinosaurs from China and North America confirm that these strange beasts were theropods. Beyond that, the poor fossil record of the group provided little information on how therizinosaurs evolved and who their closest cousins were. “*Nothronychus graffami* provided us a critical piece of the puzzle,” Zanno says. “We were able to use the anatomy of this animal as a template for researching the fragmentary remains of other therizinosaurs and gain a better understanding of their evolutionary history.”

Breaking the Mold

As part of the new study, the team combined anatomical information from 75 other theropod species, in an attempt to better understand the dietary evolution of the group and the broader implications of theropod herbivory. In constructing the family tree of a subgroup of theropod dinosaurs known as Maniraptora (the group that includes birds and their close extinct relatives), “we determined that therizinosaurs are an ancient maniraptoran lineage,” says Zanno. “This finding caused us to question our previous ideas about the dietary evolution of maniraptoran dinosaurs, including the earliest birds.”

Several maniraptoran lineages show adaptations that suggest they were not exclusively carnivorous, the beaked ornithomimosaurs (ostrich-dinosaurs) and oviraptorosaurs (egg-thieves) for instance, so the team investigated the distribution of herbivorous and carnivorous traits within a broad sample of the group. Their findings suggest that earliest maniraptorans may already have been incorporating plant material into their diet by the time therizinosaurs evolved—in other words maniraptoran ancestors were already eating plants. If so, there is the possibility that breaking from the carnivorous mold of most theropods may have enabled maniraptorans to move into new niches and diversify in ways they couldn’t before. “Something happened early in the evolution of maniraptorans that is tied to their incredible diversity,” says Zanno “the ability to feed on much more than just meat may have been one of several key innovations contributing to their ultimate success.” This finding also suggests that iconic predators like *Velociraptor*—one of the dinosaurian villains in the movie *Jurassic Park*—may have evolved from less

fearsome plant-eating ancestors. However, Zanno adds a cautionary note: “So much of the early fossil record of maniraptoran lineages is missing,” she says, “it’ll take many more fossils and decades of further study before we can generate a clear picture of why this group was so successful, and in the end, we may never fully know.”

Dinosaur Pioneers

A decade ago, therizinosaurs were unknown in North America—the clade was known exclusively by Asian representatives. The first North American therizinosaur, *Nothronychus mckinleyi*, was discovered in New Mexico and named in 2001.

The new species, *Nothronychus graffami*, belongs to the same genus but lived earlier in time. By studying the family tree of therizinosaurs, the scientific team determined that *Nothronychus* was more closely related to cousins from Asia, than to therizinosaurs living earlier in North America. Thus, they concluded that the group must have emigrated to North America from Asia in the Late Cretaceous. Sea level was high 93 million years ago, reducing western North America to a long north-to-south island surrounded by the shallow sea. Knowledge of the dinosaur fauna from this interval is limited to the *Nothronychus* and a small horned dinosaur, *Zuniceratops christopheri*, from western New Mexico. The team speculates that the migration from Asia to North America must have occurred earlier in the Early Cretaceous, when sea level was lower and dry land masses were not widely separated by the open sea.

A Curious Grave

The skeleton of *Nothronychus graffami* came as a shock to study scientists Barry Albright (University of North Florida) and David Gillette (Museum of Northern Arizona). They were excavating plesiosaurs and other sea-dwelling animals in marine rocks deposited 93 million years ago within the Western Interior Seaway in southern Utah when Merle Graffam (a Museum of Northern Arizona volunteer) discovered a toe bone that led to the excavation of the dinosaur that now bears his name. Barry Albright recounts: “Dave, the crew, and I were working on a plesiosaur excavation when Merle walked up with a toe bone in his hand and asked us what it was. Dave and I both responded that it looked like a dinosaur toe bone, and asked Merle where he found it. When he replied ‘right down the road, in the Tropic Shale,’ Dave and I almost collapsed! Then Merle added, ‘there’s a lot more!’”

Dinosaurs are land-living creatures; one group—birds—even took to the skies. Yet no dinosaurs are known to have lived in the water, so on that hot summer day encountering a dinosaur was the last thing on the crews mind. The first definitive North American therizinosaur (*Nothronychus mckinleyi*) had only just been discovered in New Mexico and had not yet been announced so the MNA team did not immediately recognize the identity of the skeleton. “Early in the excavation we were really scratching our heads,” notes Albright. “First of all, we were completely out of sorts just by virtue of having a dinosaur appear in marine sediments that would have been deposited nearly 100 miles offshore, and second, we certainly were not thinking in terms of Asian dinosaurs!”

The burial ground of the nearly complete skeleton of *Nothronychus graffami* was at least 60 miles from the closest shoreline and these ancient marine waters teemed with predators and scavengers. “A floating carcass should have been ripped apart by plesiosaurs,

sharks, and fish,” Gillette said. “Maybe instead it was stranded at sea and struggled for a few days before drowning and sinking to the bottom.”

The skeleton of *Nothronychus graffami* suffered some crushing and distortion from being buried in the seabed, so artist and fossil replica expert Rob Gaston of Gaston Designs Incorporated was brought onboard to aid with the reconstruction. “We had to work meticulously to piece together what the original bones looked like in life,” says Zanno, “it was like reconstructing the Thinker after a steam-roller accident.”

The MNA excavation was conducted in 2000 and 2001. A special exhibit on the new dinosaur and its discovery at MNA in Flagstaff, Arizona, “*Therizinosaur-Mystery of the Sickie-Claw Dinosaur*,” will close in September and be moved to the Arizona Museum of Natural History in Mesa, Arizona. The exhibit features extraordinary reconstructions by artist Victor Leshyk.

Dinosaur Burial Ground—Southern Utah

Nothronychus graffami is one of many new species of Cretaceous dinosaurs that have recently been uncovered in the remote and rugged Kaiparowits Plateau area of southern Utah in and around Grand Staircase-Escalante National Monument. Spanning almost one million acres, the Kaiparowits region represents one of the last great dinosaur boneyards in North America to be explored. Although serious scientific efforts have only been undertaken in the region since the 1980s, results of these endeavors have been spectacular. Held within the regions drab gray badlands and towering sandstone cliffs is one of the most complete records of Late Cretaceous terrestrial vertebrate life anywhere in the world. Scientists are currently studying why the fossil record of the Kaiparowits is so bountiful. One explanation proposes that the ancient lush subtropical environments of the area were periodically subjected to powerful storms that rapidly buried carcasses on coastal flood plains, or in the case of *N. graffami*, washed them out to sea. Monument Paleontologist and study co-author Alan Titus, who studied the stratigraphic context of the specimen, noted that one fortuitous outcome of the *N. graffami* specimen’s burial at sea is its association with marine shellfish that date it almost exactly to 92.5 million years ago. “This is a precision rarely afforded specimens found in terrestrial sediments and we’re thrilled to have it,” says Titus.

FIGURE CAPTIONS:

Nothronychus graffami daybreak:

At nearly 13 feet in height when upright, *Nothronychus graffami* towers at human eye level. © Victor Leshyk 2009.

Nothronychus graffami eating:

No direct evidence of *Nothronychus graffami*'s diet has been recovered. However, its anatomy and that of other therizinosaurs suggests a plant-based diet. Here, *N. graffami* is shown using its enlarged hand claws to forage for vegetation. © Victor Leshyk 2009.

Nothronychus graffami hand claws:

The gigantic unguals (claws) of therizinosaurs are evident in this photo of the reconstructed hand of *Nothronychus graffami*. The function of such large claws is unknown. However, the team speculates that they could have been used for foraging, intimidation, and/or display.

Nothronychus graffami in mangrove:

Nothronychus graffami shown foraging in a mangrove forest near the shoreline of the Cretaceous Western Interior Seaway 93 million years ago. A bull *Zuniceratops* is passing in the background. © Victor Leshyk 2009.

Nothronychus graffami skeleton in front view:

Reconstructed skeleton of the new therizinosaur species *Nothronychus graffami*, in front view, showing the characteristic long neck, small head, four-toed feet, and massive hand claws of advanced members of the group. © Rob Gaston 2008.

Nothronychus graffami skeleton in rear view:

Reconstructed skeleton of the new dinosaur species *Nothronychus graffami*, in rear view. The bones of *N. graffami* were distorted by burial in the seafloor before being excavated by the team. It took almost a year for the team and artists at Gaston Designs Incorporated to restructure the cast skeleton for display. © Rob Gaston 2008.

Nothronychus graffami in side view:

Reconstructed skeleton of the new dinosaur species *Nothronychus graffami* in side view, showing the odd body form of therizinosaurid theropods. Note the massive abdomen needed to digest plant-material, stocky legs, short tail, long neck, and small head that are characteristic of these plant-eaters. © Rob Gaston 2008.